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Construction of China's smart grid information system analysis

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ABSTRACT

The start of the smart grid program will drive significant changes of grid operation, management, customer service and social energy use patterns. Informatization as the Smart Grid "four modernizations" breakthrough feature, its importance is distinguished. The important feature, trends, construction direction of smart grid informatization will be the power companies and the IT industry issues of common concern. This article outline the construction contents of smart grid and analysis the informatization technology position in the smart grid and demand for informatization of smart grid construction. And on this basis, analyze the smart grid informatization construction system, and shows the contents of informatization construction from three different dimensionalities: the information hierarchy, power industry chain and business type. Finally, describe the contents of informatization construction and business application from five dimensionalities: data collection layer, data transmission layer, data analysis layer, information integration layer, and information showing layer.

Contents

1. Introduction

The core content of smart grid is establish open system and shared information model, integrate system data, and optimize the grid management by introducing communication, automatic control and other information technology with advanced computer, electronic equipment, intelligent components, etc. Thus form a

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network interactive and instant connection between users and users and grid companies, and realize reading data real-time, two-way and efficient, which will greatly enhance the interactive operation of power grid and improve the overall power grid reliability and efficiency.

Smart grid is an integration of most advanced communication, IT, new energy, new material, new equipment, etc. It will concentrate the essence of world technological revolution for social services directly, open a new era of power industry management and promote the revolutionary power infrastructure upgrade. In the power supply side, smart grid can support diversified power supply and change the traditional single centralized power mode, which will convenient various grid merge into and realize reliable consumptive. In the grid side, the grid operation will realize visualization, digital and intelligent; power grid enterprise will greatly enhance the level of integrated services about planning, scheduling, trading, producing and so on, and to achieve effective integration, the formation of smart grid. In the electricity customers' side, users can make two-way communication with the smart grid; according to grid information and user needs run real-time adjustment and provide efficient quality services. In the whole power system level, based on the extensive collection of information and timely delivery, through relevant regional, business and users and achieve full coordination between each other. Therefore, informatization construction system of smart grid is the key and the essence of smart grid construction system [1].

1.1. Chinese smart grid construction content

Construction of smart grid will cover power supply, power transmission, power substation, power transforming and power selling the entire business value chain, while achieving unified integration of power flow, power grid enterprise business flow and information flow.

1.2. Flexible distributed power supply

One of the advantages of smart grid is compatibility, that is supporting centralized access of big power, also can access more distributed clean energy, such as photovoltaic generation, wind power, hydropower and so on. Gridconnected operation of distributed power puts forward new requirement about power flow control of distribution network. Smart grid will provide new protection scheme, voltage control technology and instrument to satisfy two-way tide need. The meanwhile access of concentrated and distributed energy will improve power system's reliability and efficiency, provide support for peak load of power grid; at the same time, when the big grid damaged, these distributed power can form island or microgrid voluntarily and provide emergency services for hospital, transport hub, broadcast television and other important users [2].

1.3. Strong backbone frame

State Grid Corporation of China proposes that build a strong smart grid which use UHV power grid as the backbone grid and various power grid coordinated growth in an all-round way is a smart grid construction goal which fits China's national conditions. Through a united, common platform on power to conduct a comprehensive coordination, planning and running. With the large energy base to rely on, construct UHV grid consisting 100 kV ac and ±800 kV, ±1000 dc, form the power "expressway", promoting the intensive development of large coal, large hydropower, large nuclear power and large renewable energy base and realizing the optimum distribution of resources on a national wide. At the same time, guarantee the grid stability under in the long distances and big load transmission cases by senior dispatching center construction, big grid operation control technology and flexible transmission and other smart grid technologies and equipment research.

1.4. Advanced distribution automation

Compared with power transmission grid, the flexibility, automation analysis and control level of distribution grid insufficient still. Advanced distribution automation construction will be the important component part of smart grid. Advanced distribution automation will contain system's monitor and control and distribution system management functions and integration with the user, realizing load management and electricity real-time pricing. Through coordinated operation with the other component parts of the smart grid, distribution automation not only can improve system monitor, reactive power and voltage management, decrease the line loss and increase asset utilization rate, but also assist optimizing personnel dispatch, maintenance operation arrange and so on [3].

1.5. Communicational electricity equipment

In the current grid equipment, in addition to some second equipment can realize remote operation, most of the power equipment between information transmission is basically unidirectional way, while future smart grid will form a new communication and interaction mechanism realizing information interaction between grid equipments, based on which will greatly increase grid intelligent. By using the interaction of the smart grid, can realize two-way data transmission, carry out floating price system of dynamic, using senor make real-time monitoring the running state of generating power, transmitting power, distributing power, supplying power and other key equipment, when meet the power supply peak, can scheduling in different zones, balancing power supply shortage, so as to achieve optimization of the entire power system operation management and improve the stability and reliability of the grid operation.

1.6. Real-time monitoring and control of power grid

Perfect smart grid need construct grid real-time monitor system covering power generation, transmission grid and distribution grid, which can realize real-time (second to millisecond delay) comprehensive view of grid and monitor the operation of the grid through sensor. Through build power sensor system and update power system automatic control system, power performance information can provide automatic, near real-time power grid control and solve safe operation problems of the prediction, detection, and repair the power system by integrated SCADA system. Thus can find the default as soon as possible and take proper measures to quickly isolate the problem to avoid costly power outages, ensure safety and electricity grid reliability and realize grid self-healing function by perfect smart grid monitoring and controlling. Management system efficiency is getting more and more complicated, this need decentralized decision-making mechanism to be integrated, and that is smart integrated into the grid. Thereby can realize the optimization of power grid management and greatly reduce power outages [4].

1.7. Interactive terminal solutions

Smart grid is different from the traditional grid another feature is "interaction", that is can make two-way interaction with the terminal power user. Obtaining the optimal program for electricity will change the existing electricity behavior and improve customer satisfaction. The basic demand of making two-way interaction with

the terminal power user is grid enterprises can real-time collecting and tracking power information of customers, control the load, analysis and take the most economic, stable power supply scheme; at the same time, terminal equipment can transmit time prices, electricity quantity and other information to users. Therefore, in smart grid construction, the application of smart mitering device will become the basic device to achieve interaction between the two sides. Through smart mitering device, power supply enterprises can realize real-time collecting user's information and with smart mitering device integrated management software can obtain and analysis this data, master the load information and mediate power distribution. According to the power information, power supply enterprises can calculate time prices, predict price trend and mediate power scheme by user terminal smart appliances.

2. Chinese smart grid on information needs

Smart grid construction will open grid an important innovation, while informatization is the indispensable important content and change means in this innovation. The depth integration of informatization and power industry will also reflect more adequately as the smart grid construction.

State Grid Corporation of China proposes in the definition of concept of smart grid reference that, "smart grid will be a strong smart grid with the feature of informatization, digital, automatic and interactive", informatization as the Smart Grid "four modernizations" breakthrough feature, its importance is distinguished. Grid enterprises informatization started earlier, on the basis of production dispatch automation, each special application developed gradually and form an informatization system composed of information network, basic hardware and software, application systems, data resources, integration platform, information security, IT management and service and other aspects. Recently, power enterprises informatization has entered into comprehensive construction stage. In infrastructure, completed the laying of fiber optic backbone communications network and provided information channel for digital communication between devices of interaction-based. In personnel training, dispatching center and information management department in power enterprises has trained piles of talent team familiar with power production business and IT technology through years of construction in dispatch automation and management informatization. The current power enterprises informatization is changing from professional application to enterprises informatization integrated application. In this process, grid business digital degree has improved substantially. The current grid informatization construction course is the only way in smart grid construction, power enterprises informatization results has laid a good foundation for the future smart grid construction.

Under the framework of the smart grid construction, informatization construction will face new development requirements with the upgrading of grid applications [5].

2.1. Informatization will permeate all aspects of the business value chain

Currently, power enterprises informatization construction mainly concern marketing charge, enterprises recourses management and office automation and so on, while in the dispatching management, grid optimization, production management, demand side management application level is generally lagging behind. Smart grid construction will cover each link of power supply, power transmission, power selling and power using management, informatization will also become the method for each business link to realize smart. Informatization department need provide support and service for more new business, such as provide application function based on smart device, monitoring digital broadband network for devices safe integration and so on. Informatization department also need more in-depth business and following the business transformation brought by smart grid construction.

2.2. Management informatization and automation will be tightly

In the environment of smart grid construction, dispatch automation and management informatization will be more closely. Because a large number of smart device, instrumentation, and sensor will be imbedded to various grid and terminal users, at that appointed time, a large number of device state data, production real-time data, and load data will transmit through various devices and systems. The production management and management decision of enterprises all depend on these data to complete, management decision information also need effectively feedback to the grid operation and adjusted. Informatization department will need provide automation and management informatization interactive platform and environment and tool for more real-time data's safe transmission, scientific management and analysis [6].

2.3. Service-oriented information integration architecture is the development direction

Currently, power enterprises informatization construction is changing from professional application to enterprises application, information integration construction become the important measure for current power enterprises to solve the information island problem and realize information resource sharing. Smart grid construction will speed up the process of enterprise information integration.

The basic of smart grid is grid business full digital, information resource can be shared and used adequately, and realize business synergy operation. Therefore, information integration architecture will become power enterprises informatization architecture under the smart grid. Because there will be various smart device enter into network environment in different periods in the future, and in the environment based on smart grid, various application need will produce, so enterprises' information integration platform need to be a service-oriented, standard interface is available platform, also compatible with distributed and centralized information system [7].

2.4. Technology lead and business driven is equal important, informatization and business innovation deep integration

Smart grid construction will promote enterprises make vast business innovation and management innovation. The development of information technology will drive the development of business and management innovation ability, and promote enterprises research and develop more new applications and user-oriented value-added service; also, the innovation of management ability will propose higher requirements for information technology. Both promote each other, shape a sound development and upward of spiral state.

In such an environment, informatization not only plays the role of business support, but also need completely take part in the business innovation process. Though import new information technology, constantly excavate smart grid application value [8].

3. Chinese informatization architecture of the smart grid

Smart grid has three features: first, it is a high digital degree network containing various device, control system, application system and so on; secondly, it is based on unified information platform,

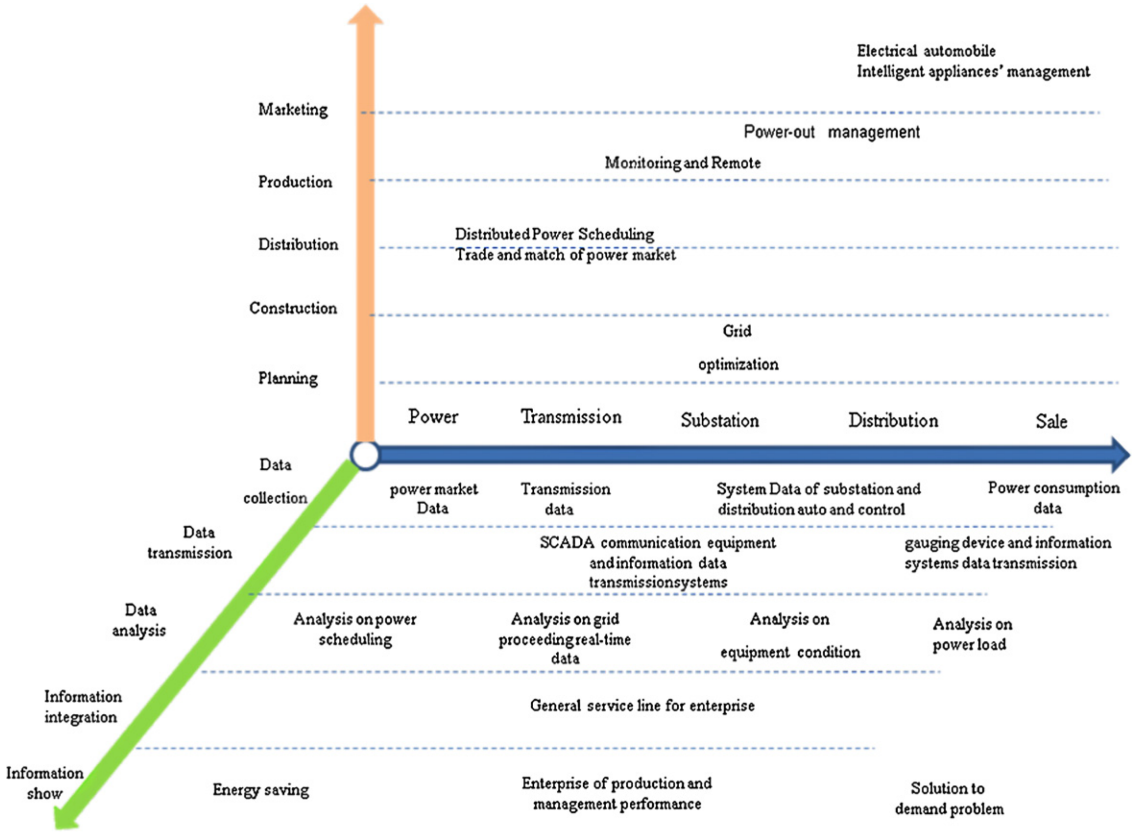


Fig. 1. Three-dimensional model of smart grid informatization construction system.

can integrate and collect data automatically; in addition, it is based on business smart analysis system, can analysis data and optimize system operation and data management [9].

Smart grid informatization construction is actually divide and combine construction system from the informatization architecture hierarchy, power industrial chain, business type the three different dimensions, as shown in Fig. 1.

Overall, smart grid informatization hierarchy including five hierarchies, bottom-up are: data collection, data transmission, data analysis and application, information integration and show, specific level division and function of each level is shown as follows.

3.1. Data collection layer

One significant advantage of smart grid is it can at the lowest level of manual intervention, enhance the initiative adjusted ability of the users' side, while using smart metering device, sensor, two-way digital communication and other technology measures, thus make grid have more elasticity, reliability and sensitivity. And grid is not a simple transmission system, but a information system. Consequently, in the smart grid upgrade process, we must establish new metering system, install new sensor, upgrade transformer substation, complete grid access facilities to adapt smart network infrastructure. New generation smart grid will use sensor, smart instrument, and digital control and analysis tools to monitor and control two-way current automatically; and use advanced micro sensor, remote meter reading equipment, monitor system, load management technology and others to realize grid fault detection, electricity consumption forecast, power system interactive control management and so on (Fig. 2).

Gradually replace smart meter and electro-optic terminal management equipment, wide area measurement systems, and other combination of smart grid; achieve central data management and hierarchical dispatching; transform electric power fiber composite cable terminal and network management system; optimize the power line communication system management and control; realize grid system in keeping with international standard, and match and optimize combination and operation with other database system, etc. Therefore, relatively perfect smart grid process system will be constituted. Power electronics technology and production is the chief component of the future power distribution system, including multifunction solid-state switch, IEDs, flexible transmission system device used for distribution (such as SVC and DStatcom) and so on. The future grid will able to use new system control logic to make them coordinated operation, so that realize integrated control of multiple power electronics device and the biggest available transfer capability of power grid.

3.2. Data transmission layer

Smart grid need collect vast device (include once, secondary device) state data and various meter measurement data. The main features of these two kinds of data are: large amount of data, collection points are many and scattered, the demand of real-time is lower than power grid real-time operation and data are needed for many system and business department. In addition, one of the main functions of smart grid is realize interactive participation for power users, its important core concept is to realize two-way information delivery and time prices, change the behaviors of power users, by "cutting the peak and valley", reduce system demand for power capacity. Real-time, two-way communication smart grid can encourage users saving energy; also allow users sell power to the grid.

For this kind of data and application features, traditional power SCADA communication is not suitable. So, in smart grid, collecting these data need adopt digital communication network based on

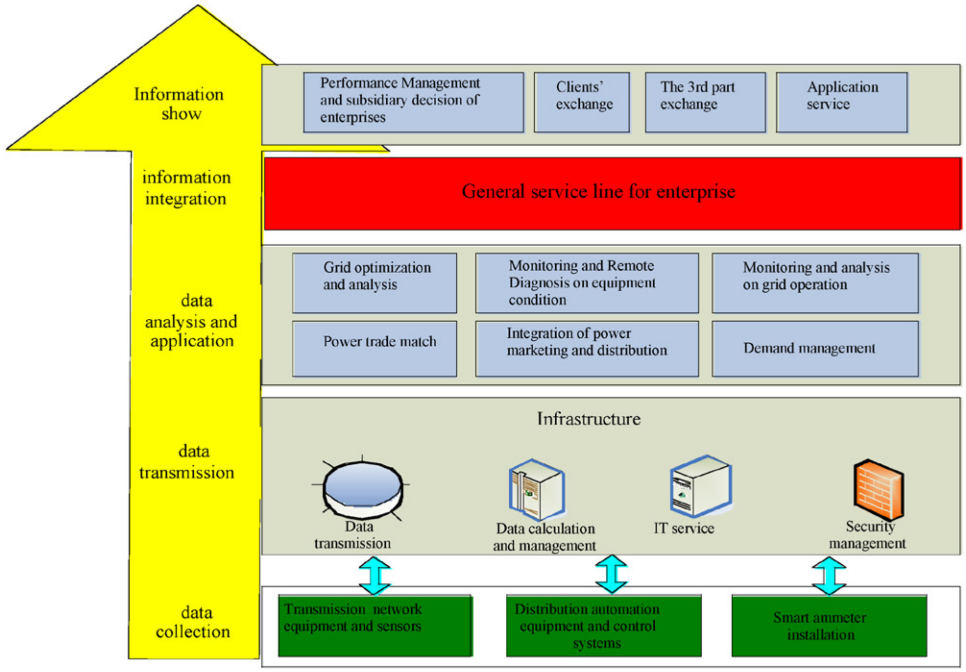


Fig. 2. Smart grid informatization construction system.

open standard, which is real-time data transmission means based on IP, and provide protocol converter which can compatible existing equipment, multi-channel shared and improve the channel utilization. Multi-channel capacity can be used by other data communication; it is more suitable for collection of vast device data and meter data. Adopting real-time data transmission based on IP, each backend systems acquire data directly by subscription form. This reduce the pressure of data channel and avoid develop multiple data interfaces between real-time system and management system, which is advantage for realize real-time data sharing.

Perfect smart grid system needs structure perfect power communication network, which is convenient for transfer collected data information and control information. Construct smart grid communication device must can support building or completing the corresponding communication network on the basis of existing power line and solve power communication problem, and promote transformer substation digitization upgrade. In addition, flexible, reconfigurable distribution network topology is also the basic of future smart grid. It will limit the scope of the fault to a minimum and recover the power supply for other parts by other collection when system meets faults.

3.3. Data analysis layer

Power grid data application and analysis optimization is the core contents of smart grid application and the fundamental expression of power grid intelligentize. But the current power grid data application in China is still in basic level. In addition to the daily business management system applications, there are very few other advanced applications. This is not enough to satisfy the application need for smart grid. Therefore, expect support business system application of daily power grid operation, smart grid should develop multi-level application in monitor, dispatch, equipment assets, and electricity trading and other aspects.

In electricity monitor and dispatch aspect. Perfect smart grid need construct grid real-time monitor system covering power generation, transmission grid and distribution grid, which can realize real-time (second to millisecond delay) comprehensive view of grid and monitor the operation of the grid through sensor. Through build power sensor system and update power system automatic control system, power performance information can provide automatic, near real-time power grid control and solve safe operation problems of the prediction, detection, and repair the power system by integrated SCADA system. Thus can find the default as soon as possible and take proper measures to quickly isolate the problem to avoid costly power outages, ensure safety and electricity grid reliability and realize grid self-healing function by perfect smart grid monitoring and controlling. Management system efficiency is getting more and more complicated, this need decentralized decision-making mechanism to be integrated, and that is smart integrated into the grid. Thereby can realize the optimization of power grid management and greatly reduce power outages. In electricity monitor and dispatch aspect, the development direction contain 3D visualization with real-time scheduling and monitoring system, global positioning system-based Wide Area Measurement System and so on.

In system fast simulation and modeling aspect. Fast simulation and modeling (FSM) is a senior software system contain risk evaluation, self-healing control and optimization (contains generalized EMS, DMS and other functions). It provide math support and prediction ability (not just to emergency response ability) for smart grid to achieve improve the stability, security, reliability and operation efficiency. FSM can provide real-time state evaluation for safe monitor, evaluation and optimization. Thus realize system performance continuous optimization and prediction simulation (safe analysis) faster than real-time to avoid the disturbance when may cause a greater impact on the system contingency happened. From the operation and programming points of view, do "what-if" analysis for power grid, and recommend proposal to operation worker. The market, policy and risk analysis to aggregate into the system model, quantify their impacts on system security and reliability at the same time.

In equipment assets integrated maintenance aspect. With the help of new information technology and communication technology, realize long-distance assets monitoring and control system; through sensor device make the site technology personnel can

acquire assets state information about power generation, power transmission, power distribution, power supply and other core equipment real-time and exactly, and ensure problems can be solved in time, thus can extend assets life observably and avoid interrupt event happen; build device assets monitor system based on long-distance network, realize long-distance monitor power device state data, master power device operation condition, and evaluate device state according to monitor data, master device health condition real-time, judge the possible fault and recommend operation maintenance personnel the unsafe factor may existing (such as judge if appear insulation cracking by monitoring oil temperature, oil chromatographic of transformer); on the basis of data collected by sensor device, control center adjust network structure and operation mode, reduce load of problem device; in power supply peak, can make real-time dispatch in different areas, balance power supply shortfall to achieve optimize management in the whole power system operation.

In power trading aspect. In smart grid mode, the range of power trade become more extensive and complex, related to the transaction object in power transmission, sale is very many. In addition to the traditional transaction object outside, will also include distributed energy and intermittent energy supply such as solar energy, wind energy and so on, and various power customers with personality requirements, at the same time, power trade also involve flexible trade mode and trade price power. Facing more complex transaction mode, relatively perfect smart grid trade matching system is needed to improve power trade efficiency, promote resources optimization distribution and realize open, fair and just in power trade, thus realize effective saving energy resources. Power trade matching system should contain inter-provincial power grid, cross auction, trade reporting, trade matching, safety checking, trade querying, intention to declare trade reporting and other function. Trade mode supported in this system contain year, month, data, short-term and one trade listed.

3.4. Information integrated layer

Information integrated layer need realize share and seamless-transition of data, order and other various information, and realize smart grid information architecture construction by establish enterprise service bus. In information system integrated aspect. After years of development, Chinese power enterprises have established numerous of automation system and management information system, including marketing, finance, materials, and projects and so on. But look at the business segments, these professional management systems dispersed in a bar; from small side, production applications based on professional need develop and construct in the transmission, substation, testing, scheduling is an independent building, cannot share information and support business collaboration and work flow. Therefore, aiming at the exiting information "island" and "chimney" in power enterprises, smart grid emphasize construct fast information channel to make data flow orderly in power grid device operation, power grid dispatch and various business systems in the engine-driven traffic, covering grid real-time operation data, grid topology data, metering data, users' data and outside application system data and so on. Thus realize information integration and form cross-sectoral, cross-system, cross-application business collaboration environment.

3.5. Information show layer

Along with the increase of metered data, smart grid need construct relevant IT device to realize comprehensive collection of such data. When process and analyze data, data warehouse can play an important role, the whole work of data analysis become simple and intuitive by using data warehouse this modern tool.

Artificial Intelligence (AI) and decision support (DSS) will used extensively. At the same time, distributed intelligent agent and they then forms the reticular control structure and other form design have key roles to realize the coordinated control within the scope of the whole system.

In the information display process, rendering and animation technology, information fast refresh, voice recognition, touch screen, holographic video, electronic map wall, "dashboard" display and other technology will play important role in smart grid analysis and decision aspect.

4. Summary

Smart grid informatization construction described in this paper is a general, commonality analysis and description of informatization system of smart grid. Specific to the state grid corporation of China and southern power grid companies, should all against their understanding, goals, key construction content of smart grid construction carry on the corresponding modification and adjustment, establish out of suitable informatization construction strategy and target, combined with maturity assessment results, propose smart grid information system frame suits the company. In smart grid construction the large environment, enterprises informatization will permeate to every link of power grid business value chain, the combination of management informatization and automation will be more closely, technology lead and business drive equal, informatization and business innovations will depth fusion. Therefore say, Chinese smart grid informatization system construction is a typical practice of our informatization and industrialization fusion important strategy.

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